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ABSTRACT

Distance learning in Connecticut has begun to develop in the wake of telecommunications (TELCO) infrastructure modernization. Progress in this area is reviewed and discussed. The state has not yet adopted a standardized statewide policy governing the delivery of educational telecommunications programing, and various private producers currently provide remote education services in the state. SciStar, a microwave delivered interactive science education distance learning curriculum, is an example of a privately produced service that participating schools purchase. The Connecticut State Department of Education is completing a two-channel instructional television fixed service that will eventually deliver instructional programing to every school in the state. The regulation and legislation involved are reviewed, and costs of private and public sector programs are explored. The present and future participation of cable television (CATV) companies is described. A look at available technology suggests that fiber is the best transmission medium for two-way full-motion audio and video where students and teacher can interact in real time. Connecticut's Public Act 92-146 is evidence that the state has taken steps to ensure that there is accountability by franchise operators for the technologies that will shape instructional uses of telecommunications. Seven tables illustrate the discussion. (Contains 42 references.) (SLD)

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Connecticut Educational Telecommunications: An Overview

Distance learning in Connecticut has begun to develop in the wake of telecommunications infrastructure modernization. Two essential components of any distance education protocol are the maximization of student to teacher interaction and the determination of the major remote education players.1 Connecticut has not yet adopted a standardized statewide policy governing the delivery of educational telecommunications programming, and various independent private producers currently provide remote education services throughout the state. **SciStar**, for example, is a microwave-delivered, interactive science education distance learning curriculum based in the Talcott Mountain Science Center in Avon.3 First airing in January, 1985, **Scistar** received its initial funding from the Aetna Life and Casualty Insurance Company. Participating schools provide fiscal support through a $950 annual fee.

The Connecticut Department of Education, (DOE) in conjunction with Connecticut Public Television, (CPTV) is completing a statewide, two-channel, instructional television fixed service, (ITFS) that will eventually deliver instructional programming to every school district in the state.4 The system presently functions in 27 of Connecticut's 165 school districts. This limited-range, low-power network relays broadcast signals via microwave transmitters from CPTV studios in Hartford. An interested school requests participation from the DOE, which, as the vendor, provides each school district with one free antenna and converter box that transforms the incoming weak ITFS signals to frequencies viewable on any conventional television set. As additional microwave transmitter towers are constructed, educational transmissions will radiate from Hartford to other areas of Connecticut. Additionally, the Connecticut Community College system has its own completed and functioning Community College Instructional Television (CCIT) microwave-delivered educational network. Lastly, a regional educational communications consortium, Area Cooperative Educational Services (ACES), provides bi-directional, interactive educational services to 27 school districts and over 720 students in the state's south-central districts.5 ACES uses a variety of communication modalities such as electronic mail and video conferencing over a fiber optic spine to service participating school districts.

Public Act 92-146: Quality of Educational Programming Standards

Connecticut's regulatory agency, the Department of Public Utility Control, (DPUC) has recently been charged by the legislature with adopting quality standards for the educational programming provided by the state's 27 cable television (CATV) companies. The recently adopted legislation is meant to comprise an additional franchise renewal criterion each CATV operator must meet under the "Length of Term" section of its proposal for renewal. (PFR) Each operator's location is illustrated in Table A. These educational telecommunications criteria are the first of their kind to be directed toward CATV companies, and are designed to mesh with national CATV trends toward interactive learning provisioning. Public Act 92-146, An Act Concerning Educational Programming, the legislative basis, was approved by the Connecticut General Assembly and became effective on July 1st, 1992. Sub-section (c) of The Act reads:

> For purposes of this section, educational technology shall include, but not be limited to: (1) computer-assisted instruction; (2) information retrieval and transfer; (3) data communications; (4) televised delivery of education programs, including cable, open broadcast and nonbroadcast; (5) development and acquisition of educational software, and (6) the instructional uses of television and other technologies.6

The DPUC has recently drafted and adopted distance learning regulations for Connecticut cable franchise operators. The language specifies that cable operators must implement technically advanced educational programming as one component in a PFR. As a recent DPUC Decision noted, ..."The educational needs of a community must be viewed on an equal footing, along with governmental and public access channels and programming."7 The educational programming requirements will comprise another plank in a Connecticut cable operator's PFR that must be serviceable if the operator expects to receive a franchise renewal award on the high end of the 5-15 year franchise renewal time frame.

The DPUC established educational precedent in case No. 92-07-13, DPUC Proceeding to Adopt Regulations Concerning Quality Standards for Educational Programming and Instructional Channels. The standards will move the state toward establishing a plan for an educational network.

Regulatory reform may be needed to support the new legislation. Presently, the Connecticut General Statutes define cable television service as:

> ...(1) the one-way transmission to subscribers of video programming or information that a community antenna television company makes available to all subscribers generally, and subscriber interaction, if any, which is required for....video programming or.... noncable communications service.8

The Connecticut General Statutes define telecommunications service as:

> ...any transmission (A) between or among points specified by the user, (B) of information of the user's choosing, ...(D) by means of electromagnetic transmission including but not limited to, fiber, microwave, and satellite...9

Regulatory reform may be required since these definitions seem to define cable television transmission as one-way while telephone transmission is two-ways. Distance learning is generally defined as "....instruction that originates at a site distant from that of the learner(s) and involves two-way communication by means of an interactive audio and (or) video component."10 Distance learning allows student-teacher interaction by audio modalities, such as phone lines. Digital signal compression technologies however, facilitate both two-way video interaction and decrease concomitant transmission costs by cramming more bandwidth and hence more programming space within extant coaxial cables.11 A strict interpretation of the existing Connecticut statutes would delimit interactive, distance learning to the state's primary local exchange carrier, Southern New England Telephone. (SNET) Recent federal legislation however, has approved video data transmissions over telephone lines, but not actual educational program production.12 A strict statutory interpretation would necessitate a Connecticut CATV company's obtaining a certificate from the DPUC to provide competitive intra or interexchange communications service in order to be permitted to transmit interactive educational programming. The legislative impact of Public Act 92-146 is that SNET is intensifying its efforts to add to its approximate 1,700 miles of intrastate fiber optic cable, increasing information-carrying capacity, and enhancing the development and eventual

implementation of distance learning networks.13 Lastly, as of September 1st, 1992, each Connecticut CATV company is under a statutory requirement to file a report with the franchising authority and with each school superintendent's office on the availability of the Company's educational and local origination channels.

Links to Learning

SNET's Links to Learning was an interactive, bi-directional full-motion video and audio distance learning trial that ran from September, 1988, through June, 1990 with 34 schools in 25 towns.14 Participating state school districts are illustrated in Table B. The trial used Connecticut's public switched telephone network to transmit voice, video, and data over the Company's existing copper telephone lines. A basic classroom interactive configuration is illustrated in Tables C and D. Such an interactive classroom can function either as a transmission or as a reception site. Links used three sophisticated technologies: full and digital compressed motion for the video link, SNET's unique packet switched network to support data collection and transfer, and a voice messaging system to support the interactive placing and receiving of messages by parents, teachers, students, and administrators. Although the Links trial ended in 1990, SNET has continued its involvement through the Telecommunications Incentive Grant Program. (TIG) The TIG provides funds typically in the $1,500 to $2,500 range for educational telecommunications projects. Grant criteria include a 20 percent funding commitment from the local community and participation in both a summer workshop and mid-year meeting.15 Remaining costs are paid by the company.

SNET-NFIE

SNET is collaborating with the National Foundation for the Improvement of Education (NFIE) in sponsoring the Learning Tomorrow program in Connecticut.16 An outgrowth of the Links to Learning trial, Learning Tomorrow is open to all K-12 public schools statewide. In March, 1992, SNET selected the Overbrook Elementary School in East Haven to receive a SNET-NFIE $30,000 educational telecommunications grant. The grant will run from September, 1992, through June, 1994. The objective is to connect a computer lab to a Local Area Network. (LAN).17

SNET technicians are currently meeting with Overbrook officials to construct a LAN to facilitate the development of educational telecommunications projects. The current plan for the SNET-Overbrook **Learning Tomorrow** effort is to tie together various computer labs with the LAN. Interactive Electronic Mail is a distance learning application currently being considered that would allow students to communicate in real time. The proposed Connecticut distance learning program shares certain affinities with the New York State Education Department's LAN project and the "Mississippi 2000" pilot distance learning project. The New York undertaking looks to equip participating classrooms with computer workstations, a teacher workstation, and with a laser printer. Each LAN would then be wired to a centralized, statewide technology network based on an IBM computer communications paradigm.18 Due in part to a projected cost in the millions, only 40 New York school systems have begun to install the necessary personal computers and LANs to configure the system, although the state legislature recently appropriated $50 million to school districts unable to afford the hardware. In Mississippi, Bellsouth's fiber optic facilities connect Mississippi State University with the rural Delta region of the state.19 In Connecticut, SNET is the only public utility that has been involved in distance learning prior to Public Act 92-146 and the incipient, statutorily mandated involvement of the various CATV companies.

Cable Company Involvement

Various Connecticut CATV companies have recently begun distance learning protocols. Sammons Communications of Connecticut, for example, in its April 7, 1992 Proposal for Renewal filed with the DPUC, provides for a distance learning return transmission line from the CATV company's headend, or primary transmission source, to each franchise area high school.20 In Norwich, elementary and junior high grade students recently collaborated to produce a tape that was aired over the local franchise operator's return line to the Norwich Free Academy. Continental Cablevision has transmitted interactive programs since 1987 and presently allocates six channels to educational access and $500,000 in production equipment and educational facilities.21 Storer Communications of Clinton, Inc., proposed in April a distance learning initiative calling for return

lines to all its franchise area high schools plus a substantial commitment by the Company to purchase and maintain all outside distribution plant.22 A recent DPUC decision mandated that Comcast Cablevision of Middletown, in central Connecticut, would construct one transmission path from each of the four franchise area high schools plus a fifth return line to a high school outside the Company's franchise area.23 The Company, in the DPUC decision, agreed to waive the costs of expensive non-standard installations, and to assume responsibility for maintaining the transmission paths and outside plant. Connecticut's CATV operators are thus responding to the regulatory mandate to use advanced technologies.

Evolution of Fiber

Table E illustrates an overview of the development of fiber optic cable in CATV companies over the past several years. Optical fiber allows a signal to be carried across greater distances than traditional copper wire, can carry more information, and is not affected by electrical interference.24 Fiber optic cable reduces the number of amplification "cascades" needed in order to compensate for signal degradation and to boost the signal carried over coaxial cable from the headend to the customer drop. One application of fiber to distance learning is the connecting of disparate educational access production studios with the franchise operator's headend, or with connecting the headend to a microwave satellite dish from which an educational program is being transmitted. "Regional Hub" architecture currently being configured by many cable operators in opposition to the older "ring-based" architectures figures to facilitate centralization of various CATV services, including remote educational transmissions.25. In Connecticut, ACES uses such a SNET built fiber optic ring-based construction in its interactive learning protocols.26

Fiber and Educational Costs

Connecticut's CATV operators are beginning to use more fiber as they upgrade and rebuild their extant systems to offer expanded channel capacities and greater broadband bandwidth and transmission capabilities. Numerous Connecticut CATV operators have begun to offer return line capabilities to the high schools in their franchise areas. Fiber optic capability makes the economics of distance learning more feasible

as the costs of the fiber and its concomitant electronics decrease, particularly as optical switching technology continues to be perfected.27 Fiber enhances broadband capability that is necessary for interactivity. As Connecticut upgrades its communications infrastructure under the auspices of the DPUC, remote learning networks will be transmitted over existing telephone networks from online information transfer centers. Fiber optic cable, with its virtually limitless bandwidth and high quality carriage capability will continue to be used more prominently in cable operators' systems, either in the supertrunk or the hub sites, or in both.28 Fiber transmission costs will continue to decrease, thus making interactive education more fiscally feasible.

DPUC actions regarding Public Act 92-146 will have lasting educational consequences as the agency works with the Board of Education and the Board of Governors of Higher Education to organize educational telecommunications projects. Connecticut thus moves in the direction other states have taken, toward the development of a formalized educational telecommunications plan. The establishment of quality standards for instructional and educational programming in Connecticut is an important initial step for the future adoption of a standardized plan for educational telecommunications. The state's distance learning initiatives figure to have applicability to both traditional and non-traditional students, as for example, in Ohio, where a distance learning protocol allows pre-release prisoners the benefit of immediate feedback from a voice messaging remote learning program administered over telephone lines.29 In Michigan, the Public Service Commission has allocated $23 million dollars for schools to use in various distance learning projects, half of which will come from telephone company retained earnings.30

There is disagreement in Connecticut regarding cost allocation of distance learning networks. Expenses vary by CATV system, since each Company is configured uniquely. The DPUC has considered ordering CATV operators to subsume all construction and labor expenses, while agreeing with the school systems' proposals that schools assume the expenses for the purchasing of classroom video equipment to produce the educational programming. Table F presents a hypothetical capital expenditure projection for any given Connecticut school system.31

Recent State Actions

Recently, additional legislation has been proposed in Connecticut regarding interactive distance learning. Representative Sidney J. Holbrook (R) has submitted a bill designed to provide bidirectional educational television to schools with the state to assume the concomitant costs, though the bill does not specify cost allocations.32. Legislation has also been proposed that would require cable franchise operators to provide interconnectivity accommodations to all franchise area public school systems for the purpose of facilitating instructional programming. The DPUC has adopted its own regulations on the establishment of quality standards for both instructional and educational channels in accordance with Public Act 92-146.33 These regulatory standards, scheduled to be adopted in early May of 1993, define educational programming as:

> ....programming generally considered to be educational in scope and in content, or provided by private independent educational programming producers, and any educational programming provided by the franchise holder.33

The Department has intended the proposed regulations to constitute an additional criterion all Connecticut cable operators must meet as part of the franchise renewal process. The Department will thus require franchise operators to consider the involvement of local educational communities of interest in making available educational programming and to accommodate educators' requests to receive instructional programming. The legislation does not attempt to determine appropriate cost allocations between the cable franchise operator and the educational communities of interest. The overarching objective is to direct the monopolist to deliver certain services designed to provide for the public well being, in the social contract sense. Since the public has spoken for more control and for regulation of cable operators, embedded subsidies to pay for distance learning costs may be appropriate in light of educators' requests to receive instructional programming. Benefits may include lower unit costs, since one teacher services many different classrooms and students, and also availability of specialized instruction to small classes or to individual students.

The most recent pending action concerning remote education is proposed legislation entitled: An Act Concerning Educational Community Antenna Television Service. The purpose of the Act is to mandate cable operators to interconnect, upon written request, public school systems for the purposes of instructional programming. Specifically, the Act states:

> To require community antenna television systems to interconnect at the request of of cooperating public school systems for the purpose of instructional programming.... The cost of such equipment and services shall be borne by the community antenna television company providing such equipment and services.34

Additionally, the proposed legislation will require the DPUC to commission a feasibility study of the state's 26 cable franchise operators for the purpose of establishing interconnectivity arrangements to provide educational or instructional programming along distance learning networks. This proposed legislation also specifies that the DPUC commission a survey by January 1, 1994, contacting each school in the state to determine whether cable franchise operators have complied with written requests from schools to provide the two-way educational or instructional programming requested. The bill would, if approved, amend extant state statutes to force the franchise operators to provide whatever technical means are required to effectuate the bi-directional, full-motion interactive audio and video educational programming as a component in the operator's PFR.

Social Contract

Although the antecedents of modern distance education lie in the correspondence school paradigm of learning first popularized in the nineteenth century, the philosophical underpinnings of distance learning may be traced to the idea of the social contract. Although most cogently articulated by the eighteenth century French social philosopher and educationist Jean Jacques Rousseau, this concept had its origins in the medieval scholastics such as St. Thomas Aquinas.35

This view suggests that the governmental "contract," an overarching covenant from which governing authority was conferred from the masses to an individual leader or governing body, rested on the philosophical leg of "summum bonum," the supreme good for the majority of the governed. Distance education benefits the majority of the governed. The operator, by providing the remote learning protocol, increases its shareholders' wealth by increasing its base of monopoly service offerings, because the monopolists's income increases as its service offerings expand, which in turn lead to an increase in overall asset base, (fixed plant and equipment) which enhances the operator's return on its investment.

The social contract is served since the public ultimately receives the benefits of the remote instruction, and the monopolist locks out potential competitive educational service providers, as the specific franchise operator is the sole purveyor of remote instruction to the educational community of interest. The operator is thus ensured of enhancing its shareholders' investment by increasing the value of its equipment. Since any competitive service provider must use the monopolist's return lines, any access fees will flow from the competitor to the monopolist. Effectively, all customers paying for the benefits associated with distance instruction are paying for the good of the entire franchise community. This is an extension of the ancient governmental function of the regulation of commerce, which in effect becomes an above-the-line rate base pass-through cost to extant ratepayers. Outside plant and equipment used to effectuate the distance protocol can be expensed through the company's normal depreciation schedules throughout its useful life, as would be any piece of distribution plant.

The DPUC believes it is the responsibility of cable operators to address the educational needs of their franchises through the provisioning of facilities and equipment necessary for technologically advanced educational programming, where such needs have been articulated as an essential part of the overall cable-related community needs. The community's educational needs must be viewed equally with governmental, educational, and public access channels and with instructional programming. Distance learning costs include classroom equipment, personnel, and in-school support services, and are viewed as the responsibility of the local educational facilities. Funding commitments for these expenses are addressed by the pertinent educational agency. However, outside plant, including return lines and educational and instructional channels, have been viewed solely within the purview of the cable operator to provide and to maintain.

A recent DPUC decision directed that the cable operator be required to assume 66% of the total $451,000 cost of installing an interactive distance network.36 The DPUC determined that the operator possessed the financial resources to purchase the necessary plant and equipment and could depreciate the costs through its normal accounting procedures. The DPUC considered outside plant items such as fiber optic and coaxial cables, laser projection devices, headend transmissions, transmitters and other electronics to be an integral part of an operator's fixed assets for which it is responsible to maintain.

With the local educational communities of interest paying 34% of the network costs, town taxpayers could fund through local taxes this portion of the network. While it may be argued that video learning is merely an adjunctive supplement to the educational services supplied by the institutions and therefore should not be subsumed by the taxpayers, there can be opposition raised to shifting additional costs to the public through a semi-public cable network. Cable subscribers are required to fund most of the cable network costs through payment of their cable and tax bills. This permits a worthwhile public policy goal through a primarily off-budget, cost-shedding funding mechanism. It remains for public institutions to determine the level of commitment to distance learning and to decide funding responsibility for these networks.37

Connecticut Distance Learning Summary

Table G presents a summary of the various remote learning technologies currently being used in Connecticut. Fiber-based fully interactive video and audio distance learning technology is still expensive, but is worth the cost if the application is diversified and shared among schools.38 Digital video signals can be combined for transmission over the same fiber cable. Fiber is the best transmission medium for two-way full-motion audio and video where students and teacher can interact with each other in real time. Connecticut's CATV companies are now beginning the initial steps toward committing to establishing remote learning networks through the use of existing coaxial return lines downstream from the company's headend to the school and upstream from the school to the headend. Fiber optic cable is slowly making its way into the state's CATV infrastructure, but has not yet been mandated for use in educational telecommunications. Digital signal compression technology however, is being considered by many Connecticut cable operators, though it appears several years away.39 This technology makes existing copper coaxial lines more valuable, because it has the net effect of creating more usable bandwidth, thus decreasing fixed transmission costs. The ability to cram additional channels into the total system bandwidth means that for the present time coaxial lines will continue to be used for some time to come, since more channels can be added without costly major system upgrades or or even costlier system rebuilds.

The effect of Public Act 92-146 also means that Connecticut has begun to take the steps to ensure that there is accountability by the franchise operators for the sophisticated technologies that will be shaping the instructional uses of statewide educational communications.40 As non-traditional students fill the ranks of Connecticut's colleges and universities, and with cable re-regulation now here, the state's CATV operators along with the franchising authority are taking the first steps in expanding the classroom via the interactive, distance learning network. Connecticut will use distance education to stimulate economic growth and development by stabilizing its current industrial bases already decimated by nationwide defense cutbacks, and by educating these work forces for complex new technologies.41

Connecticut's Cable Infrastructure Modernization

In keeping with the Clinton administration's proposed $17 billion nationwide communications infrastructure modernization initiative, Tele-Communications Incorporated's (TCI) five Connecticut franchises have embarked on an ambitious, $68 million fiber-optic project affecting 223,000 Connecticut cable television subscribers in 28 towns throughout the state.42 Educational implications include capability of two-way instructional programming complete with interactivity. The broadband bandwidth capacity will also facilitate related educational uses such as video teleconferencing, mass data storage, retrieval capability, and workplace telecommuting. TCI has also recently announced the phasing in of systemwide video compression technology, a modality that will continue to drive down transmission costs due to its ability to compress more information into the existing bandwidth.

Distance education figures to be in line with economic development initiatives in that the modernization plan TCI is implementing will create at least 200 jobs statewide, some of them dealing with the technical and administrative aspects of provisioning remote education within and across the various educational communities of interest. As fiber optic technology becomes less expensive, all telecommunications sectors will receive the ability to organize, store, and to disseminate information more easily and more effectively. Clearly, the new communications technologies will provide increased processing power for all telecommunications and CATV subscribers. Particularly with the burgeoning video dialtone technology being built into the infrastructure, the blurring of distinctions between telephone and cable will result in the formation of an informational superhighway accessible to all communications users. Lastly, distance education is the perfect enhancement of public policy goals with private investment and return on equity to investors resulting in a public and business partnership furthering the social contract; i.e., the public good.

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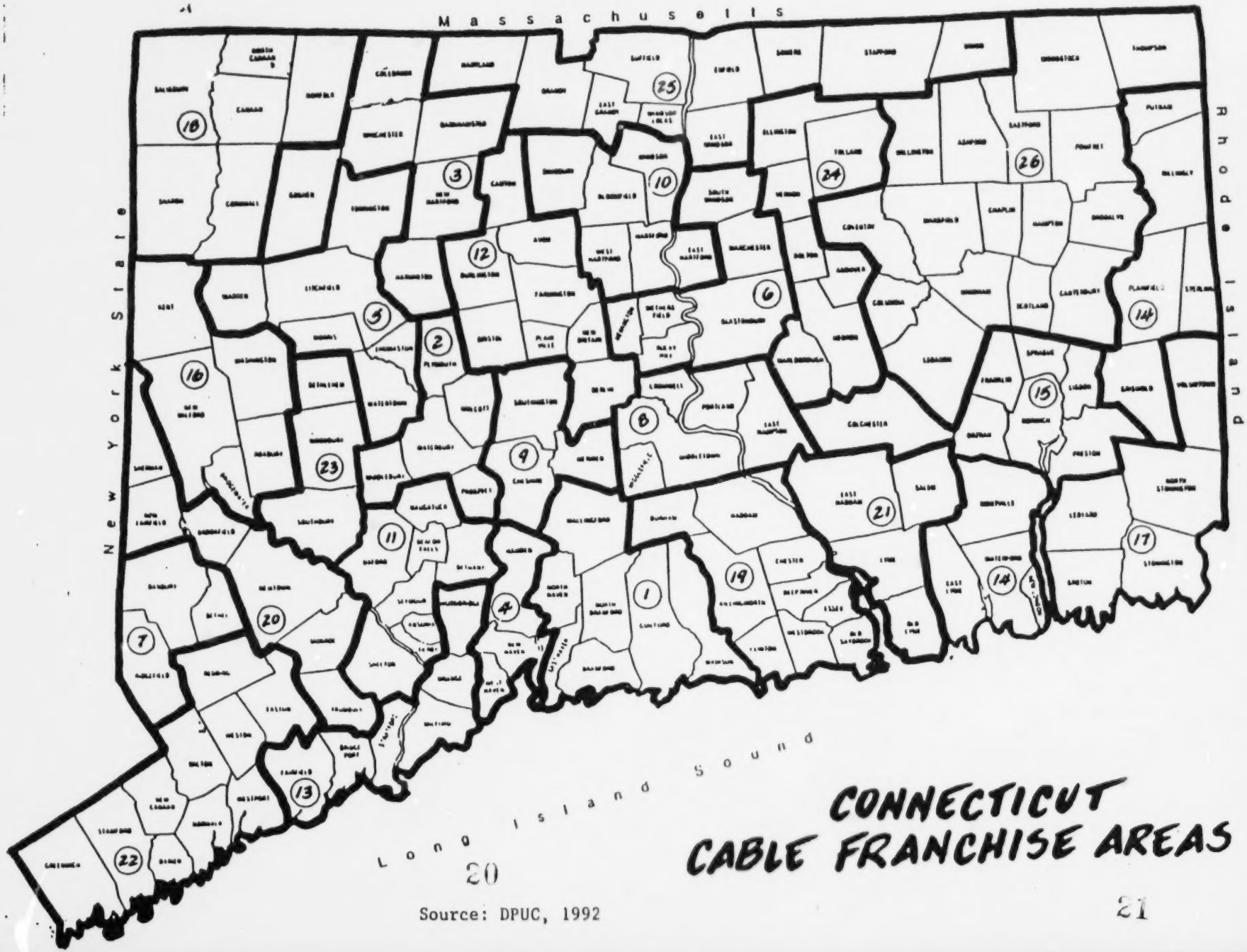
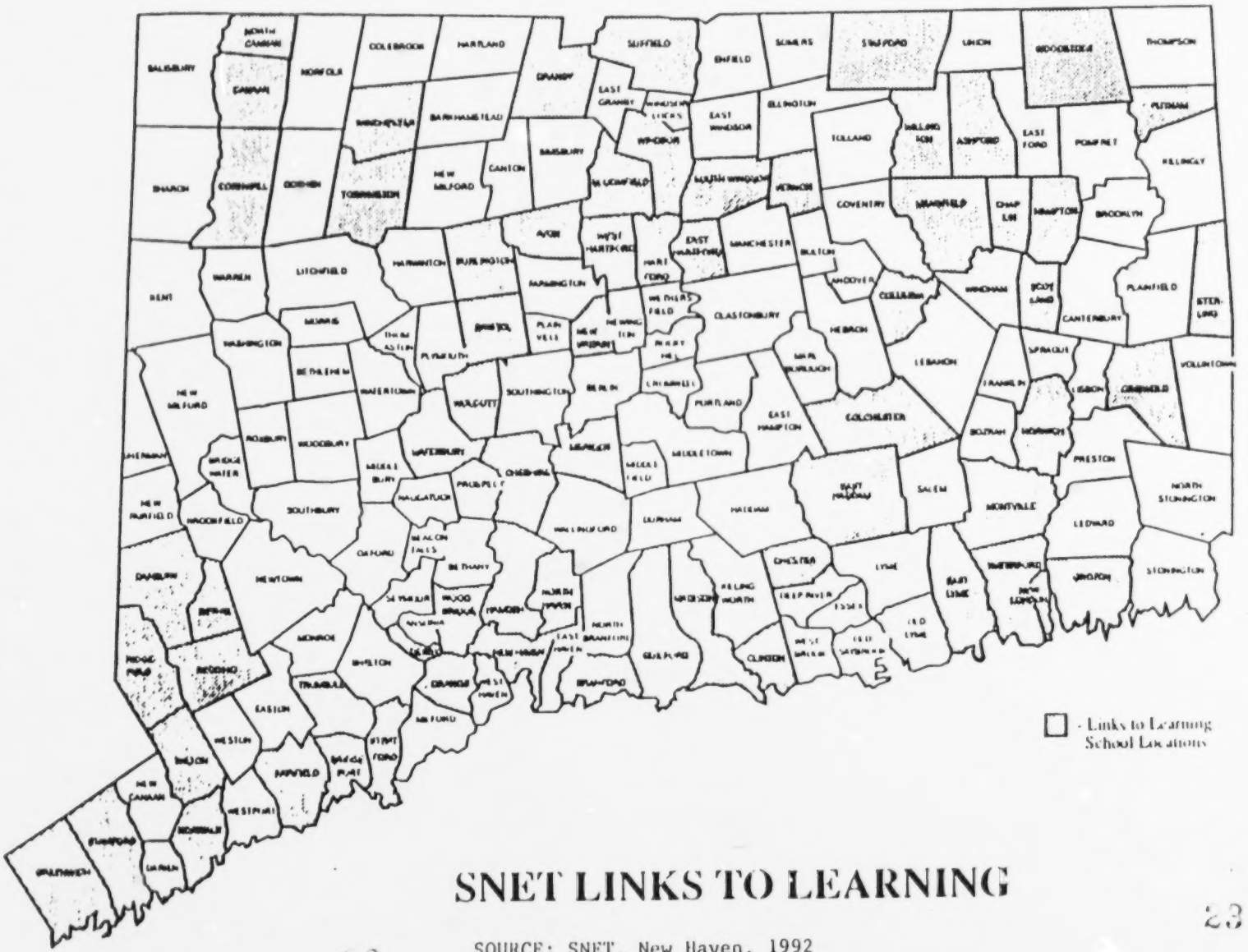
TABLE A



CONNECTICUT
CABLE FRANCHISE AREAS

Source: DPUC, 1992

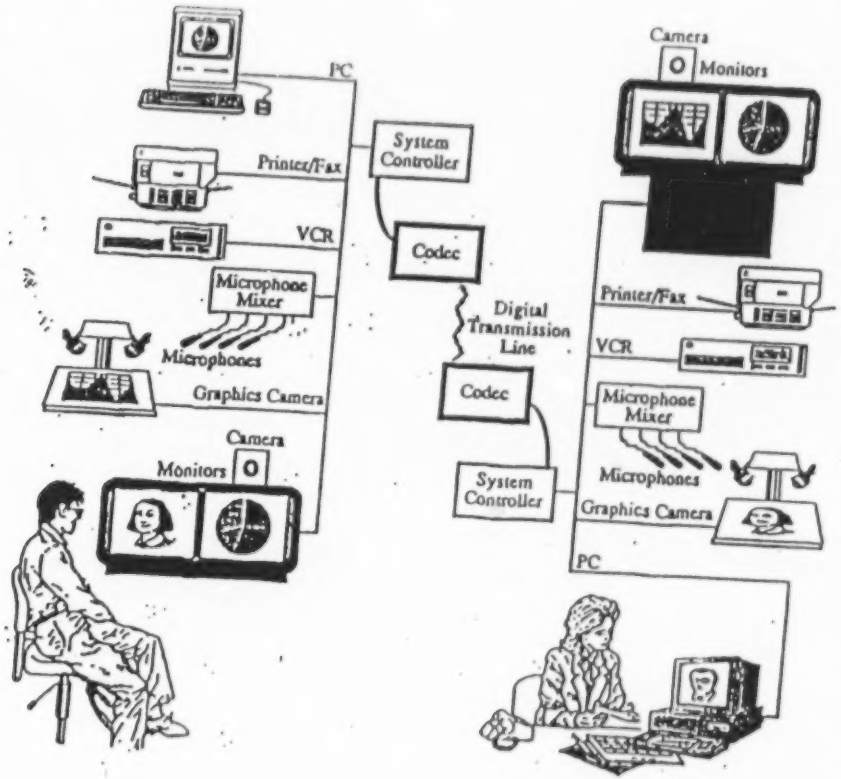
TABLE B



SNET LINKS TO LEARNING

SOURCE: SNET, New Haven, 1992

TABLE C



The basic configuration at each end includes a codec, television cameras and monitors, and an audio system. Systems can also include a room controller for adjusting camera position, audio levels, and peripheral operation.

Source: Technology Futures Inc., 1992

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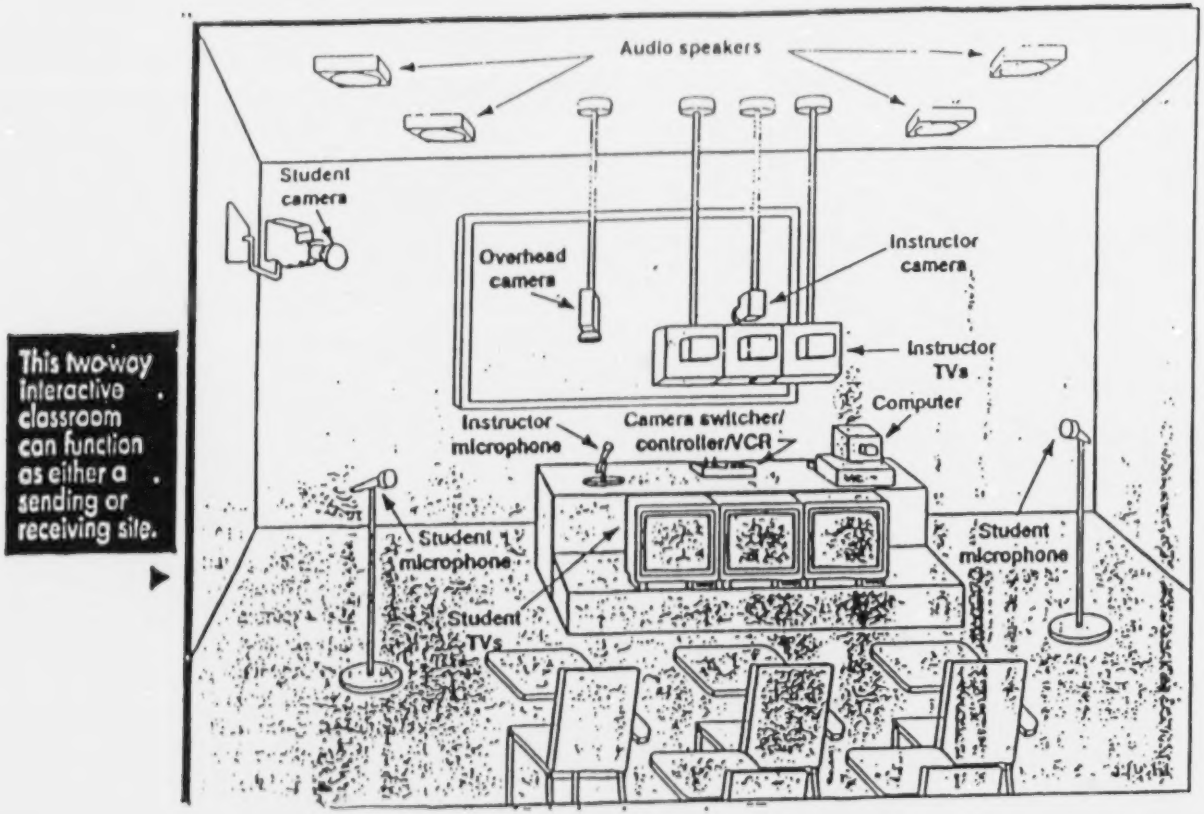
TABLE D



Source: Linking for Learning, Office of Technology Assessment, 1991.

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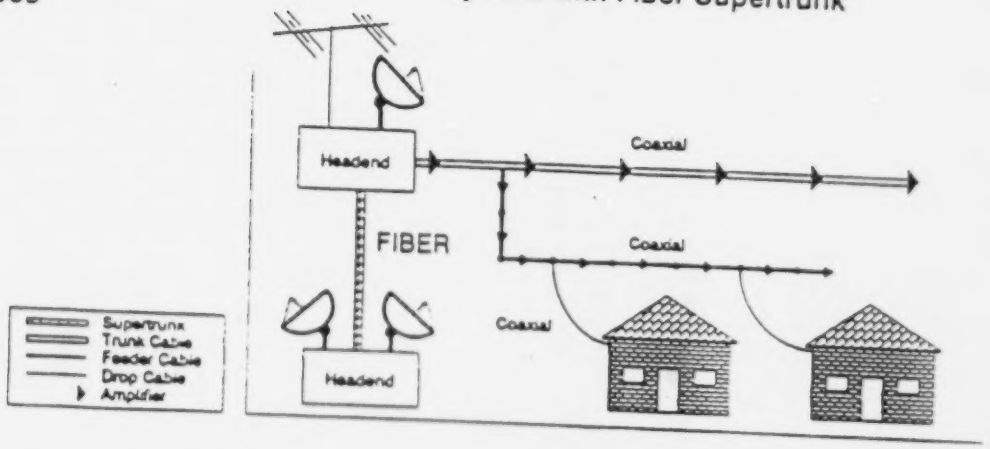
TABLE E

The Evolution of Fiber Optics in Cable

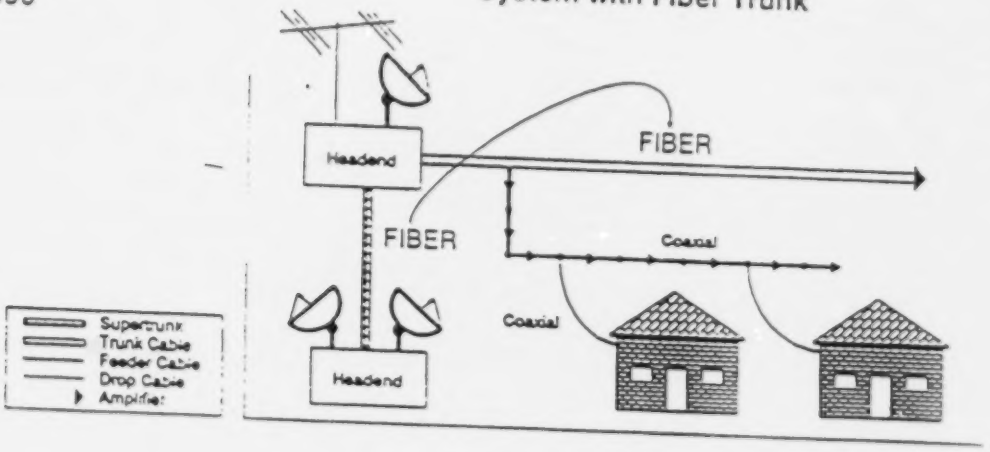
1988

System with Fiber Supertrunk



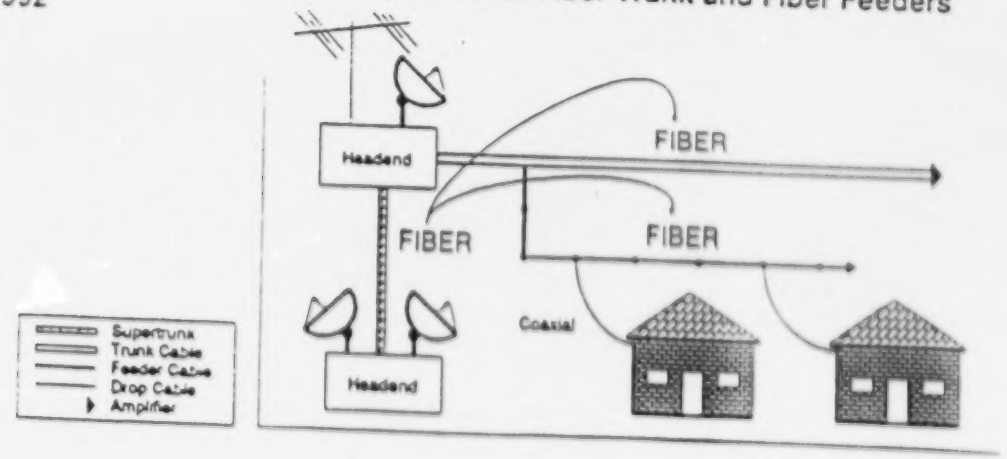
1990

System with Fiber Trunk



1992

System with Fiber Trunk and Fiber Feeders



Source: National Cable Television Association, 1992

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TABLE F

CABLE CLASSROOM EQUIPMENT COSTS
Four year acquisition plan for one site

Year 1- Minimum Receiving Site	5,375.
Year 2- Fully Equipped Receiving Site	4,425.
Year 3- Minimum Origination Site	4,890.
Year 4- Fully Equipped Origination Site	995.
	$15,685.

Cable company pays for:	
"Upstream" modulator	2,250.
Headend demodulator	2,300.
Programmable timer	700.
Switching matrix	400.
	$5,650.

Source: Middlesex Distance Learning Consortium, 1990

TABLE G

Summary of Distance Learning Technologies

- Voice teleconferencing
- Audio-graphics teleconferencing
- One-way satellite / cable networks (public)
- Microwave networks (private)
- Compensated-motion (compressed) video
- Full-motion video using digital fiber

Source: Northern Telecom, 1991